AN APPROACH TO THE CLASSIFICATION OF AGRICULTURAL AND NONAGRICULTURAL SOIL EVALUATION SYSTEMS

por

D. DE LA ROSA (1) and V. W. CARLISLE (2)

RESUMEN

UN INTENTO DE CLASIFICACION DE SISTEMAS DE EVALUACION DE SUELOS AGRICOLAS Y NO AGRICOLAS

Los reconocimientos de suelos deben incluir una fase de interpretación práctica, tanto con fines agrícolas como de ingeniería, con objeto de una mejor y más amplia utilización de su información básica. En el presente trabajo, se realiza una serie de consideraciones preliminares sobre los procesos interpretativos de evaluación de suelos, evaluación de tierras y ordenación del territorio. Se da especial importancia a un intento de clasificación de los sistemas de evaluación de suelos en base a sus objetivos principales. Se discuten las diferentes categorías de dicha clasificación y los sistemas de evaluación más representativos de cada una de ellas.

INTRODUCTION

Soil evaluation is the process of assessing soil suitability for a specified use. It is directly related to soil survey interpretation. Soil survey is the initial and obligatory phase of this process.

To identify soil evaluation objectives there is a need to differentiate clearly two terms: soil and land, which are sometimes used synonymously. According to Brinkman and Smyth (1973) soil is defined as «a three dimensional body occupying the upper-most part of the earth's crust and having properties differing from the underlying rock material as a result of interactions between climate, living organisms (including human activities), parent material, and relief over periods of time and which is distinguished from other soils in terms of differences in internal characteristics and/or terms of gradient, slope-complexity, microtopography, stoniness, and rockiness of its surface». On the other hand, the concept of land is much broader because land characteristics include soils as well as various aspects of the natural environment such as

(1) Soil Scientist, Centro de Edafología y Biología Aplicada del Cuarto, C. S. I. C., Apartado 1052, Sevilla (Spain), and previously Visiting Professor in the Soil Science Department, University of Florida.

(2) Professor in the Soil Science Department, University of Florida, Gainesville, Fla (U. S. A.).

macrotopography, vegetation, and climate. Thus soil evaluation is considered as an important part of land evaluation, since the soil is one of the central constituents of the land (Kellogg, 1961; Vink, 1962).

Land use includes all kinds of permanent or cyclic human intervention to satisfy human needs, either material or spiritual or both from the complex of natural and artificial resources which together are called land (Vink, 1975). Therefore, soil evaluation, land evaluation, and land use planning can be considered as three different processes. However, the goals of sound land use planning can only be achieved through implementation of adequate soil evaluation.

Within the context of this paper, the soil evaluation process is discussed on the basis of previously defined working units. Nevertheless, it is sometimes difficult to differentiate between soil and land evaluation. This study considers interpretation of the exclusively physical, chemical, and mineralogical soil attributes and their relation to different socio-economic aspects. It does not involve economic evaluations based on inputs and outputs, nor the parametric systems for the development of mathematical models, such as the one developed by Riquier et al. (1970).

Soil evaluation systems can be grouped in a reduced number of categories as developed by Lewis (1952) and Vink (1960). In this sense, an approach to the classification of soil evaluation systems is established. A schematic model of this classification, (Fig. 1) shows soil evaluation systems grouped with regard to primary soil uses proposed by Shaller et al. (1968). Recently used grouping developed by the USDA Soil Conservation Service (USDA, 1961, 1967, 1971, 1972, 1975), as well as the soil qualities such as productivity, fertility, degradation, and transformation are also considered.

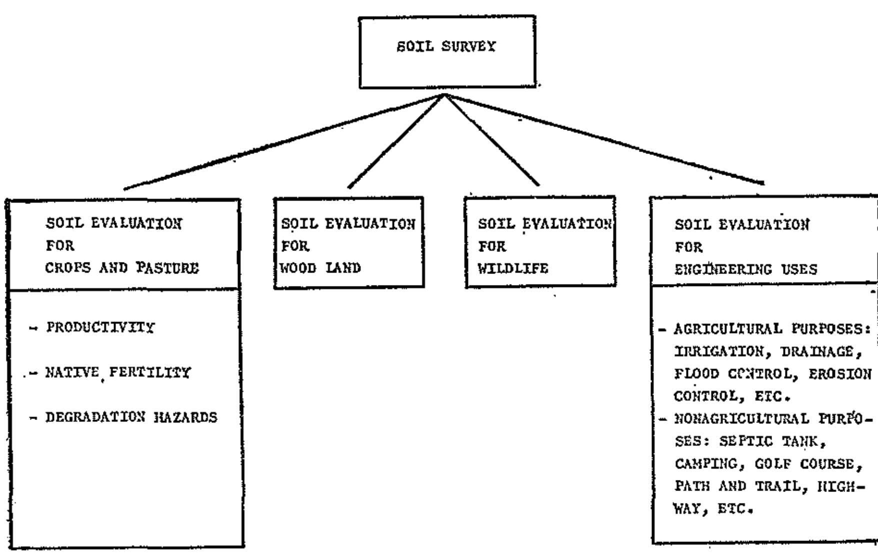

Fig. 1.—Schematic classification of soil evaluation systems for interpreting soil surveys

Soil evaluation for crops and pasture

Soil evaluation for crops and pasture includes the systems which measure soil suitability for these agricultural uses with respect to productive capacity, native fertility, or degradation hazards. For these purposes, soil evaluation systems adapted to different conditions and needs have been developed by a number of workers (Storie, 1950, 1954, 1970; Mitchell, 1950; Clarke, 1950; Odell, 1958; Ambar, 1964; Bramao and Riquier, 1964; Carstea, 1964; Sopher, 1969; SROA, 1969).

There is a need to differentiate between present and potential soil evaluations. Present soil evaluations are based on the prevailing soil conditions, as they were observed at the moment of the evaluation. Potential soil evaluations measure the suitability of soils at some future date after major improvements have been implemented. Major improvements are substantial non-recurrent inputs which can rarely be financed or extended by the individual soil user and which will effect a very significant and reasonably permanent change in the characteristics of the soil (Brinkman and Smyth, 1973).

Productive capacity

Soil productive capacity can determine the relative suitability of soils for agricultural uses. In this sense, soil potentials for crop growth are used as diagnostic criteria, without considering different levels of management. Selection of diagnostic criteria is accomplished by considering the most stable and permanent soil factors according to the present status of agricultural techniques taking into account the soil requirements for crops (De la Rosa, 1974).

Some soil evaluation systems give a measurement of soil suitability for most cultivated crops (general suitability), while other methods offer a specific soil suitability for each crop or group of crops (relative suitability). A system of soil evaluation for Mediterranean regions was proposed by De la Rosa et al. (1977) to measure the relative suitability of soils for production of various crops. In this system, the general scheme proposed by Beek and Bennema (1972) contained in the Background Document of the FAO Consultation on Land Evaluation (Brinkman and Smyth, 1973) was followed for the analysis of soil factors that are considered diagnostic criteria. Results of the application of this system to various soils series in Sevilla province, Spain (CEBAC, 1976) are presented in Table I.

Native fertility

Soil evaluations with respect to native fertility are generally based on relevant soil characteristics obtained from soil surveys. In the past, fertilizer trials have normally been conducted without much regard for soil units as described in soil surveys. However, geographic variabilities

TABLE I

Evaluations of Soils Based on the Productive Capacity for some Agricultural Uses

Soil Series	Relative Suitabilities											
	Wheat	Corn	Melon	Potatoes	Soybean	Cotton	Sunflower	Sugarbeet	Alfalfa	Peach	Citrus	Olive
Majaloba (Typic Xerofluvents).. .	I	IIc	IIc	IIc	I	IIc	I	I	I	IIc	IIc	I
La Elisa (Typic Chomoxererts)....	IIId	IItdc	IItcd	IItdc	IIId	IItdc	IIId	IIt	IIId	IVtd	IVtd	IVtd
Las Culebras (Calcic Xerochrepts).	I	I	IItc	IIc	IIt	IIc	I	I	I	IItdc	IItdc	IIItd
San Antón (Calcic Rhodoxeralfs)..	IIc	IIIc	IIIc	IIIc	IIc	IIIc	IIc	IIc	IIc	IIIpc	IIIpc	IIpc
Granujal (Aquic Haploxeralfs)	IVd	IIIptd	IVpd	IIIptd	IVpd	IVp	IVp	IVp	IVp	Vpd	Vpd	Vpd

Suitability Classes:

I — Very high
II — High
III — Moderate
IV — Low
V — Very Low

Dominant limitations:

p — Effective depth
t — Texture
d — Drainage
c — Carbonate content
s — Salinity
a — Sodium saturation
g — Profile development

of soils are now being investigated both between and within delineated soil map units. In the future, as noted by Olson (1977), progress in correlating data of soil map units will only be limited by the rate of soil map publication funding of data gathering, application of computer techniques, and statistical analysis.

A system called Fertility Capability Classification (Buol et al., 1975) was proposed for this purpose. It allows the grouping of soils from different taxonomic units that have similar fertility levels. Results of its application to soils of Brazil, Colombia, Peru, and U. S. A. suggest that the system could be used to indicate major soil fertility limitations and to group soils with similar properties that determine fertility (Cuoto et al., 1976).

Degradation hazards

Soils are grouped on the basis of their limitations to support common crops without special conditions for sufficient time with no risk of damage (SROA, 1969). For this type of soil evaluation, the emphasis is on soil conservation rather than on optimum economic yields. As Vink (1975) noted, the use of soil limitations is a different way of expressing soil conditions or soil qualities. If soil qualities are ranked on a positive scale then the use of limitations provides a negative scale.

Within this soil evaluation category, the most widely used method has been the Soil Capability System (USDA, 1961). In this system, soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to management. However, the grouping does not take into account major and generally expensive land-forming that would change slope, depth or other soil characteristics. Also, it does not take into consideration possible but unlikely major reclamation projects, and does not apply to crops requiring special management. This soil evaluation system was designed to be implemented in conjunction with detailed soil surveys and only for agricultural land use.

Soil evaluation for woodland

In general, within this soil evaluation type the soils are grouped with respect to suitability for the same kinds of trees, similar management, and potential productivity.

Similar soil evaluation systems for woodland have been developed in several countries, such as Australia (Lewis and Harding, 1963), Canada (DREE, 1969), and U. S. A. (USDA, 1967). The system utilized by the USDA Soil Conservation Service establishes woodland groups according to various criteria. This system considers mainly the potential productivity of soils based on field determinations of average site index. Site index is the height that dominant trees of a given species reach in a stated number of years on a specified kind of soil in natural, unmanaged stands.

Although all of these systems take into consideration some diagnostic criteria which are not soil characteristics, they are all considered as soil evaluation systems. In most cases, these diagnostic criteria play a secondary role.

Soil evaluation for wildlife

For wildlife soil evaluation, soil groupings are made on the basis of properties that affect the growth of different elements and kinds of wildlife habitat. For the major systems developed (Pearse, 1969; USDA, 1972; Hawes and Hudson, 1976), the following habitat elements are normally considered: grain and seed crops, domestic grasses and legumes, wild herbaceous plants, hardwood trees, coniferous plants, wetland plants, and shallow water areas. Also, the kinds of wildlife usually considered are: openland, woodland, and wetland. In the Canadian Land Inventory, a separate Soil Capability Classification for Wildlife is used (Perret, 1969; McCormack, 1971). This system emphasizes two kinds of wildlife which it considers of special importance: openland (for ungulates) and wetland. Very specific requirements are established for each.

Soil factors such as texture of the surface layer, available water capacity, surface stoniness or rockiness, and slope are the main diagnostic criteria of all these systems. However, several variables of the natural environment such as macrotopography and flood hazard are also considered.

Soil evaluation for engineering uses

All unconsolidated materials which are related to engineering structures either as structural material or as foundation upon which structures are built are considered as soil by «engineering soil science».

Within this context, soils can be evaluated under two different conditions: when soil technology is applied within an agricultural production system and when soil technology is applied within a development project of the urban, industrial, or leisure spaces.

Agricultural purposes

Soil evaluations for engineering uses with agricultural purposes classify soils into units which have similar technical needs from the point of view of certain agricultural engineering improvement. The main agricultural improvements are: introduction of irrigation, drainage, flood control structures, erosion control structures, and important alterations of slopes or the effective soil depth. Applications of soil evaluation systems developed in this sense must furnish the agropedologic and topographic data which characterize the different suitability units to facilitate technological calculation.

Of all the different soil evaluation systems for engineering uses with agricultural purposes (Desaunettes, 1962; Didic, 1964; Maletic, 1966; Cardoso, 1970), one of the most widely used is that developed by the Bureau of Reclamation (USDI, 1953). In this system, soils are grouped according to their characteristics influencing the soil water budget, soil water use efficiency, economic aspects of production, and preparation of soil for irrigation. In addition to considering the main soil characteristics as diagnostic criteria, this system takes into consideration a few informative factors such as soil use, productivity, outputs of transformation, water requirements, and drainability. Hence, several socio-economic factors have excessive importance, sometimes even more than the soil factors.

Nonagricultural purposes

Soil evaluations for engineering uses with nonagricultural purposes, classify soils into units which have similar physical requirements for urban, industrial, and/or leisure uses. For engineering interpretations the Soil Conservation Service (USDA, 1971) considers the following engineering uses: source (topsoil, sand, and road fill); sanitary (septic tank, sewage lagoons, and sanitary land fill); outdoor recreation (camping, picnicking, playgrounds, golf course fairways, and paths and trails); dwellings and light industrial buildings; local roads and streets; and highways.

In recent years, many soil evaluation systems have been developed in this field, especially for highway construction (Olinger, 1953; Evans. 1957; Olson, 1964; Elder, 1966; Montgomery and Edminster, 1966). An excellent review of soil survey interpretations for engineering uses (Bartelli et al., 1966) has been published by the Soil Science Society of America.

Characteristics and properties of soils which are highly regarded as diagnostic criteria for engineering use are: particle size, water status, strength, plasticity, compaction, expansion and contraction, temperature, reaction, corrosivity, organic matter, depth to the water table, depth to the bedrock, and slope. Estimation of these soil features is made for typical soil profiles, by layers, sufficiently different to have significance for soil engineering; and by performing a number of special determinations such as bearing capacity, upper and lower plastic limits, maximum density and optimum moisture, and shrink-swell ratings. As noted by Sowers (1965), all the relationships which involve these special determinations are empirical; however, they are valuables in predicting soil behavior when more exacting data are not available.

Systems most commonly used in classifying soils for engineering are the one adopted by the American Association of State Highway Officials (AASHO, 1961) and the one developed by the U.S. Department of Defense (USDD, 1968). The first method (cited by PCA, 1962) groups the soils according to properties that affect their use in highway construction and maintenance. Grouping soils which have similar load-carrying capacity and service together resulted in seven basic categories. Within

TABLE II

Evaluations of Soils for Some Engineering Uses

Soil Series	Suitabilities: Source of: Topsoil	Suitabilities: Source of: Road fill	Limitations: Sanitary facilities: Septic tank	Limitations: Sanitary facilities: Sewage lagoons	Limitations: Recreational areas: Picnicking	Limitations: Recreational areas: Golf course fairways	Highway AASHO Classification
Ardilla (Aquic Paleudults)	Fair: soil material too sandy	Fair: low shear strength: wetness	Severe: restricted permeability; wetness	Slight	Moderate: wetness	Moderate: wetness	A - 2 - 4 (0)
Dothan (Plinthic Paleuduls)	Poor: thin surface layer	Fair: low shear strength	Severe: restricted permeability	Slight	Slight	Moderate: restricted permeability	A - 2 - 4 (0)
Gritney (Typic Hapludults)	Poor: thin surface layer	Poor: high shring swell potential; low shear strength	Severe: restricted permeability	Moderate: slope	Slight	Slight	A - 7 - 6 (13)
Pansey (Plinthic Paleaquults)	Poor: wetness	Poor: wetness	Severe: restricted permeability; wetness subject to flooding	Severe: wetness; subjetc to flooding	Severe: wetness; subject to flooding	Severe: wetness; subject to flooding	A - 2 - 4 (0)
Stilson (Arenic Paleudults)	Poor: soil material too sandy	Fair: low shears strength	Severe: wetness	Moderate: excessive permeability	Moderate: soil material too sandy	Moderate: soil material too sandy	A - 6 (2)

each category there is a wide range in the load-carrying capacity. Hence, in the AASHO system, only the broad limits of load-carrying capacity of the soils can be stated.

Table II shows the evaluations of several soil series, in Holmes County, Florida, U. S. A. (USDA, 1975) for some engineering uses, by application of the systems used by the Soil Conservation Service, U. S. Department of Agriculture.

Acknowledgment

The senior author gratefully acknowledges the Program of Cultural Cooperation Between the United States of America and Spain; the fellowship conceded; and the University of Florida as an extraordinary host. The kind assistance and encouragement of Dr. C. F. Eno, Chairman of Soil Science Department, is greatly appreciated. Thanks are also due to Dres. T. L. Yuan and B. Zur for helpful criticism and review of manuscript.

SUMMARY

Soil evaluation systems are grouped for comparison in order to gain a better understanding of means that will improve the use of soil survey data in both farm and non-farm sectors. The base and scope of soil evaluation, land evaluation, and land use planning are briefly discussed. In this paper, emphasis is centered on an approach to the classification of soil evaluation systems on the basis of their principal objectives. Different levels of classification and the most appropriate systems of each level are discussed.

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Recibido para publicación: 12-IX-78